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APPLICATION NUMBER: 60/555,306

FILING DATE: *March 23, 2004*

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13281 U.S. PTO

032304

PTO/SB/16 (05-03)

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Express Mail Label No.

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
John Greg	Hancock	Pensacola, FL
Robert E.	Baker	Pensacola, FL

☐ Additional inventors are being named on the _____ separately numbered sheets attached hereto

TITLE OF THE INVENTION (500 characters max)

BI-COMPONENT ELECTRICALLY CONDUCTIVE DRAWN POLYESTER FIBER AND METHOD FOR MAKING SAME

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ENCLOSED APPLICATION PARTS (check all that apply)

☒ Specification Number of Pages

20

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2

☐ Other (specify)

☒ Application Data Sheet. See 37 CFR 1.76

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Respectfully submitted

SIGNATURE

Paul M. Rivard

Date

03/23/04

REGISTRATION NO.

43,446

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005205.00059

TYPED or PRINTED NAME

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22264 U.S. PTO
60/555306



032304

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<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27		Application Number	TBD
TOTAL AMOUNT OF PAYMENT (\$) 160.00		Filing Date	March 23, 2004
		First Named Inventor	John Greg Hancock et al.
		Examiner Name	TBD
		Art Unit	TBD
		Attorney Docket No.	005205.00059

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ADDITIONAL FEES</p> <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <thead> <tr> <th colspan="2">Large Entity</th> <th colspan="2">Small Entity</th> <th rowspan="2">Fee Description</th> <th rowspan="2">Fee Paid</th> </tr> <tr> <th>Fee Code</th> <th>Fee (\$)</th> <th>Fee Code</th> <th>Fee (\$)</th> </tr> </thead> <tbody> <tr><td>1051</td><td>130</td><td>2051</td><td>65</td><td>Surcharge - late filing fee or oath</td><td></td></tr> <tr><td>1052</td><td>50</td><td>2052</td><td>25</td><td>Surcharge - late provisional filing fee or cover sheet.</td><td></td></tr> <tr><td>1053</td><td>130</td><td>1053</td><td>130</td><td>Non-English specification</td><td></td></tr> <tr><td>1812</td><td>2,520</td><td>1812</td><td>2,520</td><td>For filing a request for reexamination</td><td></td></tr> <tr><td>1804</td><td>920*</td><td>1804</td><td>920*</td><td>Requesting publication of SIR prior to Examiner action</td><td></td></tr> <tr><td>1805</td><td>1,840*</td><td>1805</td><td>1,840*</td><td>Requesting publication of SIR after Examiner action</td><td></td></tr> <tr><td>1251</td><td>110</td><td>2251</td><td>55</td><td>Extension for reply within first month</td><td></td></tr> <tr><td>1252</td><td>420</td><td>2252</td><td>210</td><td>Extension for reply within second month</td><td></td></tr> <tr><td>1253</td><td>950</td><td>2253</td><td>475</td><td>Extension for reply within third month</td><td></td></tr> <tr><td>1254</td><td>1,480</td><td>2254</td><td>740</td><td>Extension for reply within fourth month</td><td></td></tr> <tr><td>1255</td><td>2,010</td><td>2255</td><td>1,005</td><td>Extension for reply within fifth month</td><td></td></tr> <tr><td>1401</td><td>330</td><td>2401</td><td>165</td><td>Notice of Appeal</td><td></td></tr> <tr><td>1402</td><td>330</td><td>2402</td><td>165</td><td>Filing a brief in support of an appeal</td><td></td></tr> <tr><td>1403</td><td>290</td><td>2403</td><td>145</td><td>Request for oral hearing</td><td></td></tr> <tr><td>1451</td><td>1,510</td><td>1451</td><td>1,510</td><td>Petition to institute a public use proceeding</td><td></td></tr> <tr><td>1452</td><td>110</td><td>2452</td><td>55</td><td>Petition to revive - unavoidable</td><td></td></tr> <tr><td>1453</td><td>1,330</td><td>2453</td><td>665</td><td>Petition to revive - unintentional</td><td></td></tr> <tr><td>1501</td><td>1,330</td><td>2501</td><td>665</td><td>Utility issue fee (or reissue)</td><td></td></tr> <tr><td>1502</td><td>480</td><td>2502</td><td>240</td><td>Design issue fee</td><td></td></tr> <tr><td>1503</td><td>640</td><td>2503</td><td>320</td><td>Plant issue fee</td><td></td></tr> <tr><td>1460</td><td>130</td><td>1460</td><td>130</td><td>Petitions to the Commissioner</td><td></td></tr> <tr><td>1807</td><td>50</td><td>1807</td><td>50</td><td>Processing fee under 37 CFR 1.17 (q)</td><td></td></tr> <tr><td>1806</td><td>180</td><td>1806</td><td>180</td><td>Submission of Information Disclosure Stmt</td><td></td></tr> <tr><td>8021</td><td>40</td><td>8021</td><td>40</td><td>Recording each patent assignment per property (times number of properties)</td><td></td></tr> <tr><td>1809</td><td>770</td><td>2809</td><td>385</td><td>Filing a submission after final rejection (37 CFR § 1.129(a))</td><td></td></tr> <tr><td>1810</td><td>770</td><td>2810</td><td>385</td><td>For each additional invention to be examined (37 CFR § 1.129(b))</td><td></td></tr> <tr><td>1801</td><td>770</td><td>2801</td><td>385</td><td>Request for Continued Examination (RCE)</td><td></td></tr> <tr><td>1802</td><td>900</td><td>1802</td><td>900</td><td>Request for expedited examination of a design application</td><td></td></tr> <tr><td colspan="6">Other fee (specify) _____</td></tr> <tr> <td colspan="4">*Reduced by Basic Filing Fee Paid</td> <td style="text-align: right;">SUBTOTAL (3)</td> <td style="border: 1px solid black; width: 100px; text-align: center;">(\$ 0)</td> </tr> </tbody> </table>	Large Entity		Small Entity		Fee Description	Fee Paid	Fee Code	Fee (\$)	Fee Code	Fee (\$)	1051	130	2051	65	Surcharge - late filing fee or oath		1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet.		1053	130	1053	130	Non-English specification		1812	2,520	1812	2,520	For filing a request for reexamination		1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action		1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action		1251	110	2251	55	Extension for reply within first month		1252	420	2252	210	Extension for reply within second month		1253	950	2253	475	Extension for reply within third month		1254	1,480	2254	740	Extension for reply within fourth month		1255	2,010	2255	1,005	Extension for reply within fifth month		1401	330	2401	165	Notice of Appeal		1402	330	2402	165	Filing a brief in support of an appeal		1403	290	2403	145	Request for oral hearing		1451	1,510	1451	1,510	Petition to institute a public use proceeding		1452	110	2452	55	Petition to revive - unavoidable		1453	1,330	2453	665	Petition to revive - unintentional		1501	1,330	2501	665	Utility issue fee (or reissue)		1502	480	2502	240	Design issue fee		1503	640	2503	320	Plant issue fee		1460	130	1460	130	Petitions to the Commissioner		1807	50	1807	50	Processing fee under 37 CFR 1.17 (q)		1806	180	1806	180	Submission of Information Disclosure Stmt		8021	40	8021	40	Recording each patent assignment per property (times number of properties)		1809	770	2809	385	Filing a submission after final rejection (37 CFR § 1.129(a))		1810	770	2810	385	For each additional invention to be examined (37 CFR § 1.129(b))		1801	770	2801	385	Request for Continued Examination (RCE)		1802	900	1802	900	Request for expedited examination of a design application		Other fee (specify) _____						*Reduced by Basic Filing Fee Paid				SUBTOTAL (3)	(\$ 0)
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SUBMITTED BY		Complete (if applicable)			
Name (Print/Type)	Paul M. Rivard	Registration No. (Attorney/Agent)	43,446	Telephone	(202) 824-3000
Signature		Date	March 23, 2004		

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BI-COMPONENT ELECTRICALLY CONDUCTIVE DRAWN
POLYESTER FIBER AND METHOD FOR MAKING SAME

FIELD OF THE INVENTION

- [01] The present invention is directed to conductive fibers and, more particularly, to bi-component electrically conductive drawn polyester fibers.

BACKGROUND OF THE INVENTION

- [02] Friction generates static electricity in synthetic fibers, such as polyamide fibers, polyester fibers, acrylic fibers, etc., and also in some natural fibers such as wool. This is a disadvantage of synthetic fibers, especially when such fibers are used in applications where the discharge of static electricity (the characteristic shock) can have serious consequences. For example, the discharge of static electricity can damage computers and other electronic equipment. In some cases, such as in flammable atmospheres, the discharge of static electricity can result in a fire or explosion. Static buildup and discharge can also affect the efficiency and productivity of fiber conversion methods such as knitting and weaving.
- [03] Because of the propensity of certain fibers to generate (or not dissipate) an electrical charge and because fibers are prevalent in many environments where static electricity is undesirable (e.g., carpet in computer rooms, clean room garments, uniforms, etc.), a large number of proposals to address the generation of static electricity have arisen. In general, these methods concern either imparting conductivity to the fibers themselves or to the article made from the fibers by

incorporating one or more individually conductive fibers in the article, or treating the fibers or article made from fibers with an antistatic surface treatment. Surface treatments are not generally desirable.

[04] U.S. Patents 5,698,148 and 5,776,608 to Asher et al. describe conductive fibers having a sheath/core configuration for incorporation into fibrous articles such as carpet or textiles. Electrically conductive carbon black is mixed in a synthetic thermoplastic fiber forming polyester to form a conductive sheath. A non-conductive core is made of the same synthetic thermoplastic fiber forming polyester used in the conductive sheath. The extruded fibers are drawn and then relaxed at a temperature above the polyester's glass transition temperature but below its melting or softening temperature.

[05] U.S. Patents 5,916,506 and 6,242,094 to Breznak et al. describe bi-component electrically conductive fibers in which a non-conductive first component is made of a first polymer, and a conductive second component is made of a second polymer containing a conductive material. The components are extruded into a sheath/core fiber, which is drawn to about four times its initial length to increase tensile strength. Such drawing causes a loss of conductivity, which can be restored by heat treatment. According to Breznak, a melting point difference between the two polymers of at least 20°C is preferred so that the heat treatment does not melt the core polymer. One drawback with this approach is that one of the polymers needs to be heated or cooled at the spinneret to account for their appreciable difference in melt temperature. This can undesirably lead to process breaks and release of monomer or oligomer at the spinneret.

- [06] Electrically conductive bi-component fibers generally exhibit a loss of conductivity upon drawing. This loss of conductivity traditionally has been counteracted by post-drawing treatments or by manipulating the drawing stage to minimize (but rarely reverse) this drop in conductivity. It would be desirable to develop a bi-component conductive fiber which does not exhibit a substantial loss of conductivity upon drawing. Such a fiber could be manufactured more efficiently by eliminating the need for post-drawing treatments or other measures aimed at increasing the conductivity of the drawn fiber.

SUMMARY OF THE INVENTION

- [07] According to one aspect of the present invention, a multi-component electrically conductive fiber has a first component comprising a first polyester having dispersed therein an electrically conductive material, and a second component comprising a second polyester which is not the same as the first polyester. The difference between the melting temperatures of the first and second polyesters is not more than about 10°C, and preferably the two melting temperatures are within about 2°C of each other. The first polyester typically is more amorphous than the second polyester before drying and/or crystallization steps performed prior to fiber spinning.
- [08] According to another aspect of the present invention, a method of preparing a drawn multi-component electrically conductive fiber is provided. The method comprises co-extruding a first component comprising a first polyester having dispersed therein an electrically conductive material and a second component

comprising a second polyester which is not the same as the first polyester. The fiber is thereafter drawn, while applying heat, to form a drawn fiber.

- [09] In preferred embodiments of the present invention, the drawn fiber, even without further treatment, has an electrical conductivity which is not substantially less than the electrical conductivity of undrawn fiber. In some cases, the electrical conductivity of the drawn fiber, surprisingly, is greater than that of the undrawn fiber. By avoiding the need for a separate post-drawing treatment for increasing conductivity, there exists the potential to increase manufacturing efficiency and cost effectiveness.

BRIEF DESCRIPTION OF THE DRAWINGS

- [10] The objects, features, and advantages of the invention will be apparent from the following more detailed description of certain embodiments of the invention and as illustrated in the accompanying drawings in which:
- [11] FIG. 1 is a cross-sectional view of a bi-component conductive fiber having a PBT center and a PET-based conductive component in accordance with a preferred embodiment of the invention; and
- [12] FIG. 2 is a schematic illustration of a typical spinning process for preparing a bi-component fiber in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

- [13] The multi-component fiber of the present invention is prepared from a first polyester and a second polyester which is not the same as the first polyester. By “not the same” it is meant that the second polyester is prepared from a different combination of monomers than those used to prepare the first polyester. Commercially available polyesters can be used for each of the first and second polyesters, or suitable polyesters can be readily prepared by persons of ordinary skill. The term “multi-component” is used herein to refer synthetic fibers having more than one polymeric component and is particularly inclusive of bi-component fibers.
- [14] The multi-component fibers of the present invention are useful in a wide variety of applications such as textiles, industrial fabrics, and carpets. It is also contemplated that the multi-component fibers may be useful in other applications such as non-woven fabrics and, if further cut or processed, possibly in adhesives, interlayers, and the like.
- [15] The first polyester generally functions as a carrier for the electrically conductive material in the first component of the multi-component fiber. The first polyester preferably is more amorphous than the second polyester, which improves compounding of the carbon and may also help to improve tenacity of the resulting fiber. The first polyester preferably is a polyethylene terephthalate (PET) based copolymer. The polyester may be modified, if necessary, so that its melting temperature is relatively close to (or possibly the same as) that of the second

polyester. The difference in melting temperature between the first polyester and the second polyester is less than about 10°C, preferably is less than about 5°C, and even more preferably is about 2°C or less.

[16] There are several known methods to lower the degree of crystallinity and/or the melting temperature of a polyester. For example, many polyesters are prepared with a third monomer which is either a diol or a diacid (or is diacidic in reactivity). One example is PET modified with glycol, which is commercially available as PETG. Polycycloterephthalate (PCT) modified with glycol is commercially available as PCTG, while an acid-modified version of PCT is commercially available as PCTA. The acid-modifier is often a difunctional terephthalate such as dimethyl terephthalate or dimethyl isophthalate. Other difunctional acids, such as adipic acid, maleic acid, the different isomers of phthalic acid, and similar materials can be used. The diethyl ester versions of various diacids may be preferred to the diacid itself. Non-limiting examples of diol or glycol modifiers include ethylene-, diethylene-, and propylene glycols, butanediol, cyclohexanedimethanol, and other difunctional alcohols.

[17] One preferred PET based polyester is available pre-blended with conductive carbon black from Americhem, catalog no. 19420-F25, which has a melting point of about 225°C. Examples of other polyesters include a copolymer of terephthalic acid (TA), ethylene glycol (EOH), and cyclohexanedimethanol (CHDM), such as one of the Eastman PETG products. Other non-limiting examples of polyesters include polytrimethylene terephthalate (PTT) based polymers and polybutylene

terephthalate (PBT) based polymers. Many other polyester-based carbon compounded materials are commercially available, such those available from Americhem under catalog nos. 16131, 16222 and 19420. RTP Company also has a line of carbon black filled polyester products which are marketed specifically for static control applications, under the name PermaStat[®]. Such materials may be useful in making antistatic fibers with appropriate carbon loadings. In general, in order to obtain conductivity with carbon black-filled polymers, the amount of carbon black in the polymer is such that it cannot be used to form a fiber by itself. The bi-component fibers described herein allow for heavily carbon-loaded polymers to be used in fibers by using a second polymer as the supporting substrate in the filament.

[18] The second polyester generally is non-conductive and may be used to form the core, for example, in a sheath/core type fiber. One preferred polyester for the second component is polybutylene terephthalate (PBT), which is derived from two main monomers, terephthalic acid (TA) (or dimethyl terephthalate (DMT)) and butanediol (BDO). See "Handbook of Thermoplastic Polymers," Fakirov ed., 2002, Wiley-VCH. PBT has a melting point of about 223°C. Other polyesters alternatively can be used in the second component, such as polytrimethylene terephthalate (PTT), copolymers based on PTT or PET, copolymers such as PETG or PCT, or other polyesters useful in forming single-component fibers known to those skilled in the art.

[19] The electrically conductive material may be conductive carbon black or other conductive material, such as conductive metals. Preferably, carbon black is

dispersed in the first polyester. The loading of conductive material in the first component can vary over a wide range but most often ranges from about 10% to about 50% by weight, more usually from about 20% to about 30% by weight.

[20] The multi-component fiber of the present invention preferably does not exhibit a substantial decrease in conductivity after drawing. Preferred fibers may exhibit a reduction in linear resistance after drawing by as much as 100 to 1,000 times. For example, when using PBT as the non-conductive polyester and Americhem 19420-F25 as the carbon-filled polyester (25% carbon loading), it was found that the bi-component fibers consistently exhibited a decrease in linear resistance from 10^8 - 10^9 ohms/cm to 10^6 - 10^7 ohms/cm after drawing. This means that the conductivity, of efficacy in reducing static charge, improved by a factor of approximately 100 times.

[21] The fibers typically are spun using about 11-13% of the conductive first component laid on the non-conductive second component as longitudinal stripes, as shown in FIG. 1. Alternatively, the first and second components of the multi-component fiber can be arranged as a sheath/core or any other suitable configuration presently known or hereafter developed for multi-component fibers. The particular arrangement of the first and second components forms no part of the present invention. The bi-component fiber typically is spun at from about 1,000 to 2,000 meters per minute (mpm) and most often at about 1400 mpm. FIG. 2 is a schematic illustration of a typical fiber spinning process which can be used to prepare the bi-component fibers of the present invention.

- [22] The spun fiber can be drawn using any suitable equipment, such as a four roll Erdmann drawstand. The roll temperatures preferably are set above the glass transition temperatures of the polyesters. Typical drawing temperatures range from about 100 to about 190°C. In one preferred embodiment, the first and fourth rolls are set at 90°C and the remaining two “draw rolls” are set at 150°C. The fourth roll is normally called the relaxation roll, and is typically set at a temperature at or higher than the glass transition temperature (T_g) of one or both of the polymers. Retention and/or improvement in conductivity was observed over a wide range of relaxation temperatures, both above and below T_g .
- [23] One potential benefit from the relatively low differential in melt temperature between the first polyester and the second polyester is that the fiber can be manufactured using a common temperature at the spin pack. In other words, because of the similar melt temperatures, neither polyester is required to undergo an increase or decrease in temperature at the spinneret. This should translate into lower occurrences of process breaks and smoother processing due to less released monomer or oligomer at the spinneret.
- [24] The following examples are provided for illustrative purposes only and should not be regarded as limiting the invention.

Example 1

- [25] This example illustrates preparing a bi-component fiber in which polybutylene terephthalate (PBT) was used for the non-conductive second component and a PET-based polyester, Americhem 19420-F25 (with 25% carbon loading), was

used for the conductive first component. Extrusion conditions are summarized in the following table.

Machine Variable	Conductive PET-based Component	Non-conductive PBT
PROFILE TYPE	PBT	PBT
Extruder zone 1	240	240
Extruder zone 2	245	245
Extruder zone 3	250	250
Flange	250	250
Transfer line	250	250
Meter Pump Outlet	260	260
Pack adapter	260	260
Pack well		258

- [26] A bi-component fiber was spun with 11-13% of the carbon-carrying polyester laid on the PBT polymer as longitudinal stripes. The fiber was spun at 1400 mpm to give an approximately 45 denier fiber with tenacity of approximately 1.3 – 1.5 g/denier. The following table summarizes spinning conditions:

1st godet mpm	1400
2nd godet mpm	1420
Tension at windup	6-7 gms
Winder mpm	1425
Chimney air	150 cfm
Finish	12% oil in water
Target OOI	1.0-1.2 %
Target denier per position	45 +/- 2
Percent carbon component	11.5%
Stripes	3/fil

- [27] The linear resistance of the undrawn fiber was measured and was found to be about 10^8 - 10^9 ohms/cm. Linear resistance was measured in this and other examples herein using either a Keithley 614 electrometer or Keithley 6517 electrometer/high resistance meter. Fiber samples were 7.5 cm in length. Either 5 or 10 measurements were made and an average and standard deviation calculated.

Fiber denier was measured using a reel of known circumference and the denier calculated as grams/9000 meters. Fiber tenacity was measured using an Instron 8100 tensile testing meter using Instron's Merlin software and was calculated as the breaking strength divided by denier.

- [28] The spun fiber was drawn on a four-roll Erdmann drawstand, of which the first and fourth rolls were set at 90°C and the other two “draw rolls” were set at 150°C. Drawing conditions are summarized in the following table.

Setting	Target Value	Units
D Roll Speed	1021.0	Mpm
A/Feed Ratio	1.050	
B/A Ratio	1.210	
C/B Ratio	1.520	
D/C Ratio	1.000	
Friction/D Ratio	0.970	
Total Draw Ratio	1.93	
Feed Roll Speed	528.7	Mpm
A Roll Speed	555.1	Mpm
B Roll Speed	671.7	Mpm
C Roll Speed	1021.0	Mpm
Friction Roll Speed	990.4	Mpm
A Temp	90	°C
B Temp	150	°C
C Temp	150	°C
D Temp	90	°C

- [29] The linear resistance of the drawn fiber was measured and was found to be about 10^6 - 10^7 ohms/cm. The tenacity of the fiber was measured and found to be about 2 g/denier.

Comparative Example 1

- [30] This example illustrates preparing a bi-component fiber in which PBT was used for both the carbon-carrying component and the non-conductive second

component. The carbon-carrying component was loaded with 25% of conductive carbon black. The fiber was spun and thereafter drawn essentially as described in Example 1. Tensile results and conductivity results are typical of several hundred items prepared using this combination of polymers, with varying amounts of carbon component, spinning speeds, and drawing temperatures.

Example 2

- [31] This example illustrates preparing a bi-component fiber in which a PET-based polyester, Americhem 19420-F25 (with 25% carbon loading), was used for the carbon-carrying component and the non-conductive second component was PTT. All other details are essentially as described above in Example 1.

Example 3

- [32] This example illustrates preparing a bi-component fiber in which PBT filled with 25% carbon black was used for the carbon-carrying component and the non-conductive second component was PTT. All other details are essentially as described above in Example 1.
- [33] Table 1 below summarizes the linear resistance and tenacity of the fibers of Example 1, Comparative Example 1, Example 2, and Example 3. The ratio of drawn to spun linear resistance indicates whether or not conductivity was unchanged (ratio = 1.0), conductivity improved (ratio < 1.0), or conductivity decreased (ratio > 1.0).

Table 1

Example	Denier as spun	Denier after drawing	Effective Draw (Spun/ Drawn Denier	Spun Linear Resistance (ohm/cm)	Drawn Linear Resistance (ohm/cm)	Ratio: Drawn resistance /Spun resistance	Spun Tenacity (g/den)	Drawn Tenacity (g/den)
1	45	25	1.8	5×10^7	8×10^6	0.16	1.2	2.00
Comp. 1	45	25	1.8	3.5×10^6	1.5×10^7	4.3	0.87	1.48
2	45	25	1.8	2.0×10^8	3.8×10^9	19.0	1.11	1.40
3	45	25	1.8	3.3×10^6	3.3×10^7	10.0	0.99	1.10

[34] The fiber of Example 1 exhibited about 35% more drawn tenacity than the fiber of Comparative Example 1 prepared under the same processing conditions, speeds, etc., with the same polymer processing temperatures. The fiber of Example 1 thus provides improved tenacity over the fiber of Comparative Example 1 while still permitting the two polymers of the bi-component fiber to be processed at the same temperature because of their similar melting temperatures. Further, the fiber of Example 1 had better conductivity after drawing than did either the fiber of Comparative Example 1 or fibers, as in Examples 2-3, which were made with different combinations of polyesters with other conditions being identical (in the cases where the melt temperatures are the same) or changed to reflect the particular melt properties of polymers with different melt temperatures.

[35] Table 2 below summarizes a number of other test items generated using different grades of PBT as the non-conductive material, compared with various conductive materials and two nylon-based conductive fibers. "19420" refers to Americhem 19420-F25 (with 25% carbon loading). These results show the superior retention of properties with the appropriate choice of polymer pairs versus other combinations of polymers. The examples in this table were made using a fiber cross-section where the conductive material appears as stripes along the longitudinal direction of the threadline. "% Stripe" is the weight percent of the conductive polymer in the filament (where, in each case, approximately 25% of the conductive polymer weight is carbon black). The two columns showing "Avg Ohms/Cm" show the linear resistance in ohms/cm of (1) Spun (or Sp) and (2) Drawn (or Dr) fibers. The last column shows the ratio of drawn to spun linear resistance, where the ratio of drawn to spun linear resistance indicates whether or not conductivity was unchanged (ratio = 1.0), conductivity improved (ratio < 1.0), or conductivity decreased (ratio > 1.0).

Table 2

Core	Stripe	% Stripe	% Core	Avg of Sp Ohms / cm	Avg of Dr Ohms / cm	Avg of Dr / Sp Ohm
PBT - A	PBT - 1	10	90	2.58×10^6	1.37×10^7	5.46
PBT - A	PBT - 1	13	87	2.59×10^6	7.45×10^6	2.99
PBT - A	PBT - 1	16	84	2.12×10^6	6.48×10^6	3.34
PBT - B	PBT - 2	10	90	3.49×10^6	1.37×10^7	4.09
PBT - B	PBT - 2	13	87	2.12×10^6	4.99×10^6	2.35
PBT - B	PBT - 2	16	84	4.13×10^6	6.47×10^6	2.40
PBT - A	19420	13	87	5.33×10^7	1.12×10^7	0.21
PBT - A	19420	16	84	4.80×10^7	6.15×10^6	0.13
PBT - B	19420	10	90	9.60×10^7	1.52×10^7	0.16
PBT - B	19420	13	87	4.80×10^7	9.28×10^6	0.20
PBT - B	19420	16	84	4.00×10^7	7.40×10^6	0.19
PBT - C	PBT - 1	10	90	3.76×10^8	1.78×10^7	37.33
Nylon 66	Nylon 6	10	90	9.25×10^5	1.19×10^7	13.03
Nylon 66	Nylon 6	13	87	1.01×10^6	1.34×10^7	13.18
Nylon 66	Nylon 6	10	90	8.61×10^5	4.06×10^6	4.77
Nylon 66	Nylon 6	13	87	6.59×10^5	3.20×10^6	4.84
Nylon 66	Nylon 6	16	84	6.72×10^5	3.09×10^6	4.57

[36] It will be understood that while the invention has been described in conjunction with specific embodiments thereof, the foregoing description and examples are intended to illustrate, but not limit the scope of the invention. Other aspects, advantages and modifications will be apparent to those skilled in the art to which the invention pertains, and these aspects and modifications are within the scope of the invention, which is limited only by the appended claims.

WHAT IS CLAIMED IS:

1. A multi-component electrically conductive fiber comprising:
 - a first component comprising a first polyester having dispersed therein an electrically conductive material, wherein the first polyester has a first melting temperature; and
 - a second component comprising a second polyester which is not the same as the first polyester, wherein the second polyester has a second melting temperature;wherein the difference between the first melting temperature and the second melting temperature is not more than about 10°C.
2. The multi-component electrically conductive fiber of claim 1 wherein the first polyester is a copolymer of terephthalic acid, ethylene glycol, and one or more modifiers selected from the group consisting of diethylene glycol, propylene glycol, butanediol, cyclohexanedimethanol, adipic acid, maleic acid, and phthalic acid.
3. The multi-component electrically conductive fiber of claim 1 wherein the first polyester is a polybutylene terephthalate (PBT) based polymer.
4. The multi-component electrically conductive fiber of claim 1 wherein the first polyester is a polytrimethylene terephthalate (PTT) based polymer.

5. The multi-component electrically conductive fiber of claim 1 wherein the second polyester is polybutylene terephthalate (PBT).

6. The multi-component electrically conductive fiber of claim 1 wherein the second polyester is polytrimethylene terephthalate (PTT).

7. The multi-component electrically conductive fiber of claim 1 wherein the electrically conductive material comprises carbon black.

8. A method of preparing a drawn multi-component electrically conductive fiber, the method comprising:

preparing an undrawn fiber by co-extruding a first component comprising a first polyester having dispersed therein an electrically conductive material and a second component comprising a second polyester which is not the same as the first polyester, wherein the first polyester has a first melting temperature and the second polyester has a second melting temperature, wherein the difference between the first melting temperature and the second melting temperature does not exceed about 10°C; and

drawing the undrawn fiber while applying heat to form a drawn fiber.

9. The method of claim 8 wherein the drawn fiber has an electrical conductivity which is not less than the electrical conductivity of the undrawn fiber.

10. The method of claim 8 wherein the first polyester is more amorphous than the second polyester.
11. The method of claim 8 wherein the electrical conductivity of the drawn fiber is greater than the electrical conductivity of the undrawn fiber.
12. The method of claim 8 wherein the first polyester is a copolymer of terephthalic acid, ethylene glycol, and one or more modifiers selected from the group consisting of diethylene glycol, propylene glycol, butanediol, cyclohexanedimethanol, adipic acid, maleic acid, and phthalic acid.
13. The method of claim 8 wherein the first polyester is a polybutylene terephthalate (PBT) based polymer.
14. The method of claim 8 wherein the first polyester is a polytrimethylene terephthalate (PTT) based polymer.
15. The method of claim 8 wherein the second polyester is polybutylene terephthalate (PBT).
16. The method of claim 8 wherein the second polyester is polytrimethylene terephthalate (PTT).

17. The method of claim 8 wherein the electrically conductive material comprises carbon black.

18. A method of preparing a drawn bi-component electrically conductive fiber, the method comprising:

preparing an undrawn fiber by co-extruding (i) an electrically conductive first component comprising a copolymer of terephthalic acid, ethylene glycol, and one or more modifiers selected from the group consisting of diethylene glycol, propylene glycol, butanediol, cyclohexanedimethanol, adipic acid, maleic acid, and phthalic acid; the copolymer having dispersed therein electrically conductive carbon black, and (ii) a non-conductive second component comprising polybutylene terephthalate; and

drawing the undrawn fiber at a temperature from about 80 to about 190°C to form a drawn fiber; wherein the drawn fiber has an electrical conductivity which is not less than the electrical conductivity of undrawn fiber.

19. The method of claim 18 wherein the drawn fiber has an electrical conductivity which is greater than the electrical conductivity of the undrawn fiber.

ABSTRACT OF THE DISCLOSURE

A multi-component electrically conductive fiber has a first component having a first polyester having dispersed therein an electrically conductive material. A second component includes a second polyester which is not the same as the first polyester. The difference between the melting temperatures of the first and second polyesters is not more than about 10°C. Preferred multi-component fibers do not exhibit a substantial loss of conductivity after drawing and, in some cases, actually exhibit an increase in conductivity after drawing.

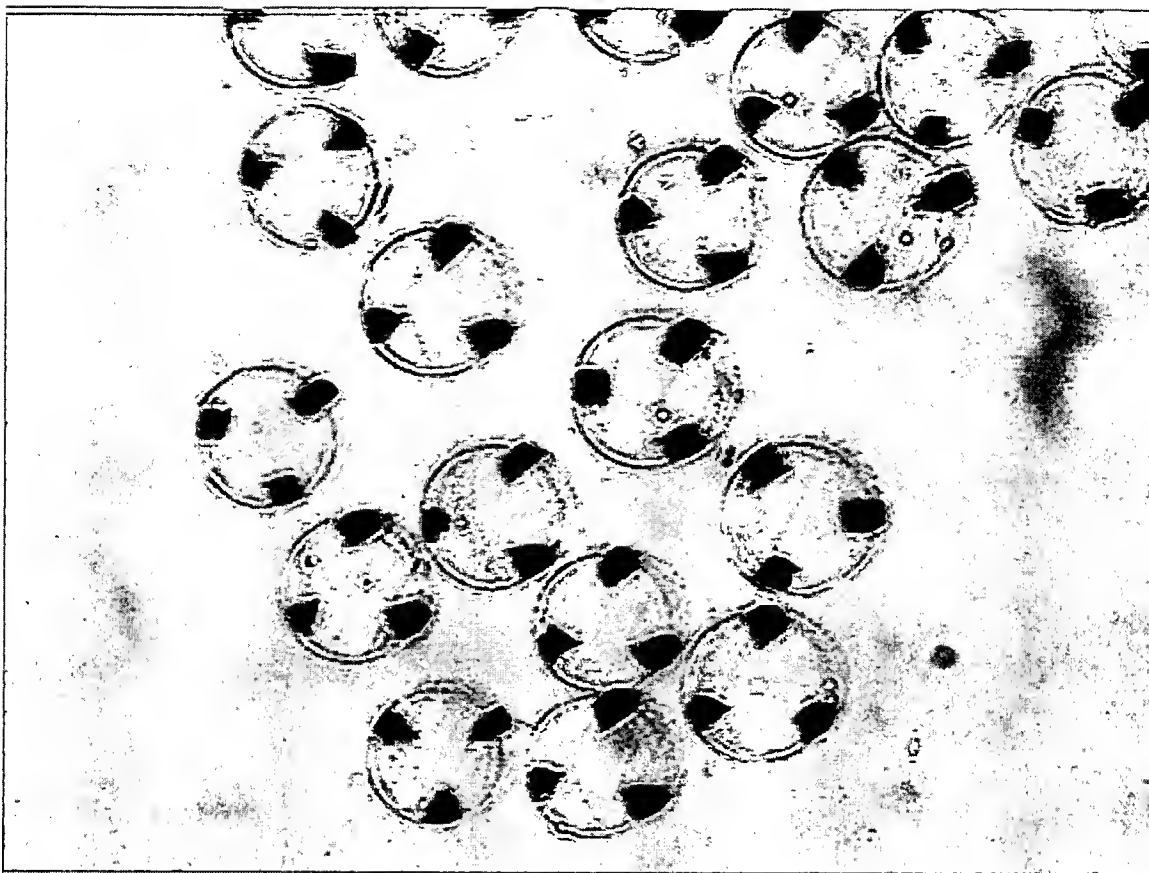


Fig. 1

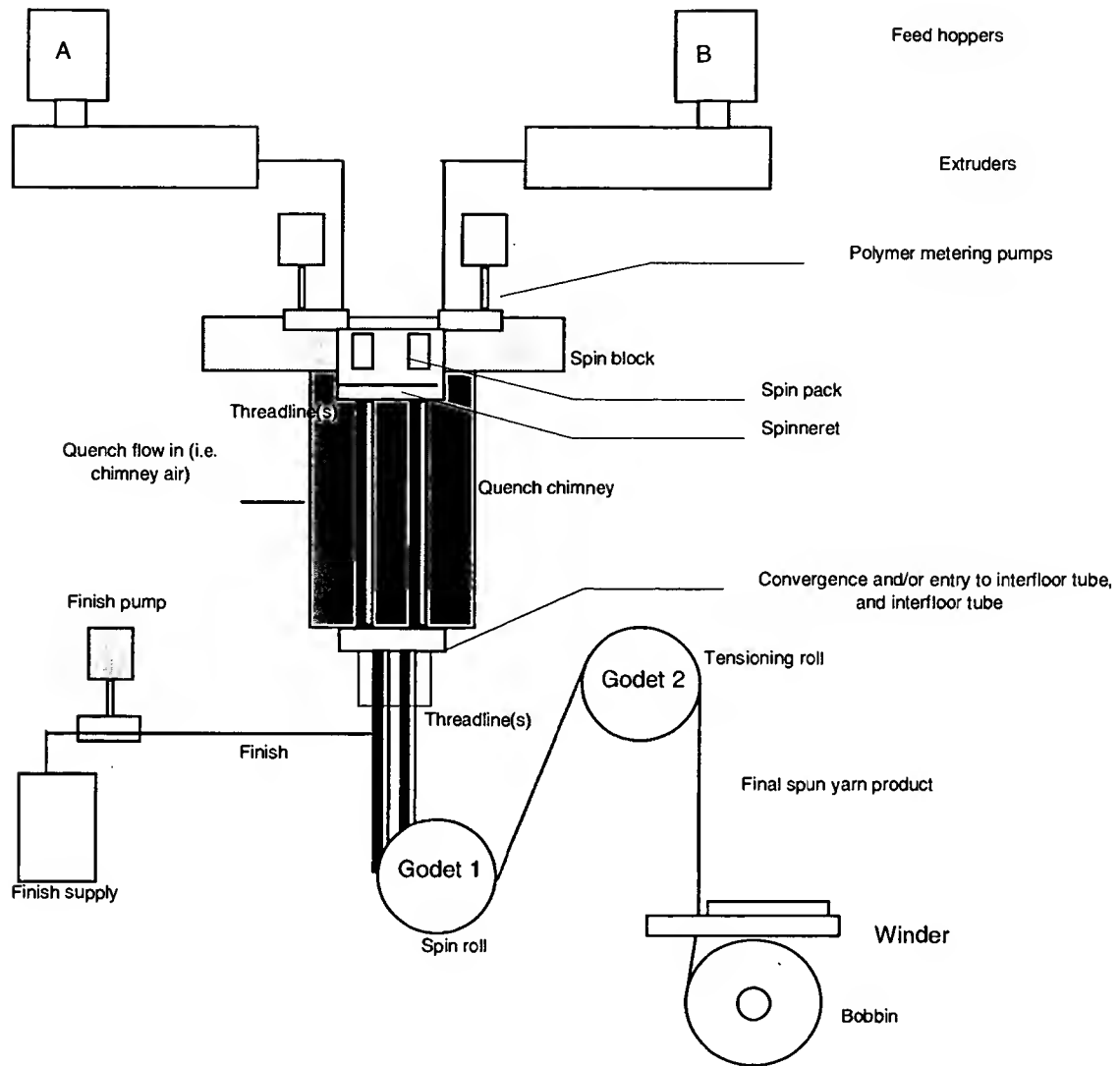


Fig. 2

Application Data Sheet

Application Information

Application number:

Filing Date:

Application Type:

Provisional

Subject Matter:

Utility

Suggested classification:

Suggested Group Art Unit:

CD-ROM or CD-R?:

None

Number of CD disks:

Number of copies of CDs:

Sequence submission?:

Computer Readable Form (CRF)?:

Number of copies of CRF:

Title:

BI-COMPONENT ELECTRICALLY CONDUCTIVE
DRAWN POLYESTER FIBER AND METHOD
FOR MAKING SAME

Attorney Docket Number:

005205.00059

Request for Early Publication?:

NO

Request for Non-Publication?:

NO

Suggested Drawing Figure:

Total Drawing Sheets:

2

Small Entity?:

NO

Latin name:

Variety denomination name:

Petition included?:

NO

Petition Type:

Licensed US Govt. Agency:

Contract or Grant Numbers:

Secrecy Order in Parent Appl.?: NO

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Representative Information

Representative Customer Number: 22907

Domestic Priority Information

Application:	Continuity Type:	Parent Application:	Parent Filing Date:

Foreign Priority Information

Country:	Application number:	Filing Date:	Priority Claimed:

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